

WHAT IS CLAIMED IS:

1. A semiconductor device comprising:  
a metal wiring provided on a semiconductor  
substrate;

5 an anti-metal diffusion film formed on the metal  
wiring;

a buffer layer which is formed on the anti-metal  
diffusion film and includes at least a silicon-methyl  
radical bond and a silicon-oxygen bond; and

10 a low-dielectric constant film layer which is  
formed on the buffer layer and includes at least the  
silicon-methyl radical bond and the silicon-oxygen  
bond,

wherein the silicon-methyl radical bonding density  
15 of the buffer layer is less than the silicon-methyl  
radical bonding density of the low-dielectric constant  
film layer.

2. A semiconductor device according to claim 1,  
wherein a film thickness of the buffer layer is not  
20 more than 30 nm.

3. A semiconductor device according to claim 1,  
wherein a specific dielectric constant of the low-  
dielectric constant film layer is not more than 3.1.

4. A semiconductor device according to claim 1,  
25 wherein a silicon-methyl radical bonding density  
relative to a silicon-oxygen bond in the buffer layer  
is not less than 22%.

5. A semiconductor device according to claim 1,  
wherein a silicon-methyl radical bonding density  
relative to a silicon-oxygen bond in the low-dielectric  
constant film layer is not less than 25%.

5           6. A semiconductor device according to claim 1,  
wherein the metal wiring is a copper wiring, and the  
copper wiring is embedded in a surface portion of  
an insulating film layer provided on the semiconductor  
substrate having an element devices formed thereto.

10           7. A semiconductor device according to claim 1,  
wherein the anti-metal diffusion film is a methyl  
radical-containing silicon nitride film.

            8. A semiconductor device according to claim 1,  
wherein the anti-metal diffusion film is a methyl  
15           radical-containing silicon carbide film.

            9. A semiconductor device according to claim 1,  
wherein the anti-metal diffusion film is a laminated  
film of a methyl radical-containing silicon nitride  
film and a methyl radical-containing silicon carbide  
20           film.

            10. A semiconductor device according to claim 1,  
wherein the buffer layer is a first methyl radical-  
containing silicon oxide film formed by using an  
organic silicon compound containing a methyl radical as  
25           a raw material.

            11. A semiconductor device according to claim 1,  
wherein the low-dielectric constant film layer is

a second methyl radical-containing silicon oxide film formed by using an organic silicon compound containing a methyl radical as a raw material.

12. A semiconductor device according to claim 1,  
5 further comprising an upper metal wiring layer which is connected to the metal wiring through the low-dielectric constant film layer, the buffer layer and the anti-metal diffusion film.

13. A manufacturing method of a semiconductor  
10 device comprising:

forming an anti-metal diffusion film on a metal wiring provided on a semiconductor substrate; and

forming a buffer layer including at least  
a silicon-methyl radical bond and a silicon-oxygen  
15 bond on the anti-metal diffusion film and forming a low-dielectric constant film layer including at least the silicon-methyl radical bond and the silicon-oxygen bond on the buffer layer,

wherein the buffer layer is formed in such a  
20 manner that its silicon-methyl radical bonding density is less than the silicon-methyl radical bonding density of the low-dielectric constant film layer.

14. A method according to claim 13, wherein a film  
thickness of the buffer layer is controlled to be not  
25 more than 30 nm.

15. A method according to claim 13, wherein  
a specific dielectric constant of the low-dielectric

constant film layer is controlled to be not more than 3.1.

16. A method according to claim 13, wherein the buffer layer is film-formed in such a manner that  
5 a silicon-methyl radical bonding density relative of a silicon-oxygen bond is not more than 22%.

17. A method according to claim 13, wherein the buffer layer is formed under a pressure being controlled to be not more than 3 torr during the film  
10 formation.

18. A method according to claim 13, wherein the buffer layer is formed by an RF (Radio Frequency) power density being controlled to be not less than  $2 \text{ W/cm}^3$ .

19. A method according to claim 13, wherein a flow  
15 rate ratio of the methyl radical-containing organic silicon compound and oxygen is controlled to be 1:5 during the buffer layer formation.

20. A method according to claim 13, wherein the low-dielectric constant film layer is formed in such  
20 a manner that a silicon-methyl radical bonding density relative to a silicon-oxygen bond is not less than 25%.

21. A method according to claim 13, wherein the metal wiring is a copper wiring, and the copper wiring is embedded in a surface portion of an insulating film  
25 layer provided on the semiconductor substrate having element devices formed thereto.

22. A method according to claim 13, wherein

a methyl radical-containing silicon nitride film is used for the anti-metal diffusion film.

23. A method according to claim 13, wherein a methyl radical-containing silicon carbide film is  
5 used for the anti-metal diffusion film.

24. A method according to claim 13, a laminated film of a methyl radical-containing silicon nitride film and a methyl radical-containing silicon carbide film is used for the anti-metal diffusion film.

10 25. A method according to claim 13, wherein the buffer layer and the low-dielectric constant film layer are formed by using an organic silicon compound containing a methyl radical as a raw material.

26. A method according to claim 25, wherein the  
15 buffer layer and the low-dielectric constant film layer are continuously formed without turning off a power supply.

27. A method according to claim 13, wherein the  
20 buffer layer and the low-dielectric constant film layer are discontinuously formed by turning on a power supply again.